203

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ROCK HOLE HABITATS OF A FERAL POPULATION OF *AEDES AEGYPTI* ON THE ISLAND OF ANGUILLA, WEST INDIES

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In the New World, *Aedes aegypti* (Linn.) is associated with a well defined range of immature habitats, principally small to large artificial containers. On Anguilla, West Indies, two distinct populations have been identified; a domestic population with immatures principally in large domestic underground water storage cisterns and old asphalt drums, and a rock hole population. The latter habitat was first cited by Belkin and Heinemann (1976) from a collection made by A. Guerra during August 1966. The rock hole population has since been found to be truly feral and rock holes containing immature *Ae. aegypti* occur at distances up to more than 1 km from the nearest human habitation.

The island of Anguilla lies between 62°58′ and 63°11′W, and 18°10′ and 18°17′N in the northeastern Caribbean and is 25 km long by just over 5 km wide at its widest, with a total land area of about 83 km²; its long axis is oriented WSW to ENE. Anguilla is composed of limestones on a volcanic base, and is low lying and undulating, reaching up to 65 m on the north coast. The ridge along the north coast dips SSE to the south coast. Throughout the island are a number of depressions from a few tens of meters across to several kilometers, which contain the cultivable soil. Most of the remainder of the island is covered with cactus/thorn scrub, highly modified by erosive goat browsing and with little or no ground cover. The ground in these areas is mostly bare rock slabs or broken rock with sparse soil. The soil cover is eroded, and the limestone is considerably weathered into karst solution holes, varying from a few mm to 1.5 m diam. The rainfall is low and erratic with no clear rainy season in most years, although there is an overall tendency of higher rainfall during September–November (Table 1). Because of the low rainfall, water is often carried into the bush for tethered sheep and goats; a potential method of distributing domestic mosquitoes.

Participants in the Second *Aedes aegypti* Eradication Campaign, begun in 1972 under one of the authors (SM), were aware of the feral mosquito problem. Rock holes immediately adjacent to houses were identified and treated, and eventually an extra sprayman was employed specifically to treat rock holes. The second Campaign was discontinued in 1976, and no control was undertaken until 1981 when the Third Eradication Campaign was started under another of the authors (AGP). A more extensive search of the island was conducted recently, identifying *Ae. aegypti* positive rock holes over a wide area and at considerable distances from houses.

Karst holes over 100 mm in diam, by about 50 mm deep that will hold at least 20 mm of water serve as larval habitats for *Ae. aegypti* (Fig. 1). Holes that will hold water are associated both with continuous rock and with slightly raised limestone slabs, from 2 – 50 m², interspersed with broken rock and soil pockets. Coral rock formations of these types occupy at least 17 km² of the island with a hole density of 20–100 ha.⁻¹ Surveys made during February and September 1982 indicated that between 5 and 75 percent of rock holes containing water also had *Ae. aegypti* (Table 2). The overall percentage of positive rock holes sampled during February and September were 22.8 and 43.2 respectively.

The number of larvae in rock holes is very variable, attaining about 1000 immatures per m² of flooded rock hole area. Larvae occur in holes in full or partial shade, and occasionally in full sunlight, also

Table 1. Monthly rainfall at The Valley, Anguilla.[1]

Month	51 year mean[2]	1981–82[3]
January	62 mm	35 mm
February	39	173
March	37	32
April	64	29
May	105	121
June	65	10
July	79	89
August	102	39
September	130	55
October	130	184
November	130	39
December	83	108
Total	1,026	914

[1] Unpublished data from the Department of Agriculture and Fisheries, Government of Anguilla.
[2] Period 1931 to 1981.
[3] Monthly total October 1981 to September 1982.

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Fig. 1. Three rock holes above Limestone Bay (elevation approximately 50 m) in semi-shade; currently dry, but earlier contained *Aedes aegypti* larvae (ruler length is 0.31 m).

in bare rock holes or those containing leaf litter and/or soil. Larval densities are usually higher in the presence of debris. Food seems to be a limiting factor of the rock hole habitat, as larvae brought into the laboratory and kept in the original water develop faster and with a higher success rate when food is added. Initially, feral larvae are difficult to rear in the laboratory, but successive generations do not present difficulty.

A single rock hole was monitored for immature mosquitoes from 8 February to 29 September 1982. This hole is situated about 100 m from the nearest house in an extensive area of rock holes. It is 1.2 m × 0.24 m × 0.1 m deep and has limited shade cover. At one end there is a layer of leaf litter, the remainder has a thin mud layer over its rock bottom. During this time, the hole filled eight times, drying out three times before adults emerged. The water level rose about 5 mm for each 1 mm of rainfall. The average evaporation rate was 15–20 mm daily except when there was extensive cloud cover. The water temperature fluctuated between 27 and 33°C, depending upon the time of day. Pupae were first seen 8 to 10 days after flooding, and the longest period of continuous activity was 30 days from 9 February to 11 March (the actual period was longer as the hole already had 4th stage larvae present on 9 February). Normally there was only a 4 to 5 day period for emergence before the hole became dry.

Several offshore cays are associated with Anguilla, but of the three examined (Anguillita, Prickly Pear East and West), no suitable larval habitats for feral *Ae. aegypti* were detected. This is due to the more broken nature of the rock, and greater soil and ground cover leaving no holes capable of holding water above the coastal splash zone.

This is the fourth report of *Ae. aegypti* using rock holes in the Caribbean region. It is analogous to the situation observed by Fox et al. (1960) at Aguadilla, Puerto Rico, in which *Ae. aegypti* were collected on four occasions from July to December 1959. Those rock holes occurred in a rough outcrop of limestone, 23–27 m above sea level, adjacent to the Bay of Aguadilla and were 25–90 m from the closest human dwelling. From the photographs in Fox et al. (1960), the rock holes on Puerto Rico appear very similar to those on Anguilla, but are not as abundant. Nathan and Giglioli (1982) observed *Ae. aegypti* in rock holes on Cayman Brac in peridomestic situations within 6 m of buildings.

A slightly different situation occurs in Kaimosi Forest of Kenya where Garnham et al. (1946) noted *Ae. aegypti* immatures in rock holes in large granite boulders, usually in deep shade, but occasionally in sunlit spots. Mattingly (1952) discussed the rock hole habitat in Africa and from his remarks and those of Robinson (1950), this habitat is primarily considered as a dry season refuge.

The feral population is referable to *Aedes aegypti* sensu stricto, although they tend to be dark (Dr. Yiau-Min Huang, personal communication). The 5th hindtarsomere is rather dark, a condition noted by Dr. Huang in specimens from a similar habitat in Tonga. Studies are being conducted to determine the degree of genetic difference between the domestic and feral populations of *Ae. aegypti* on Anguilla, the degree of reproductive isolation and vector competence.

At present, it is not known whether the rock hole populations of *Ae. aegypti* on Anguilla are of conse-

Table 2. Survey of rock hole sites at nine localities on Anguilla during February and September 1982.

Locality	No. wet holes examined Feb.	No. wet holes examined Sept.	No. positive Feb.	No. positive Sept.	Percent positive Feb.	Percent positive Sept.
Limestone Bay	19	8	11	6	58	75
Blackgarden	26	7	11	5	42	71
Northside	17	19	4	8	24	42
Shoal Bay	27	15	11	5	41	33
Merrywing Road	39	all dry	2	0	5	0
Chalvilles	46	36	10	9	22	25
Island Harbour	44	20	2	12	5	60
Mount Fortune	28	10	5	5	18	50
West End*	—	3	—	1	—	33
Total	246	118	56	51	22.8	43.2

* A survey was not made at West End during February.

quence in the transmission of dengue, but these populations will pose problems for vector control and eradication programs.

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LARVAL *AEDES AEGYPTI* FROM TUVALU PAPAYA TREES

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Formerly called the Ellice Islands, Tuvalu comprises 9 low-lying atolls totalling some 26 km² in land area; strewn across (5–11°S, 176–180°W) about 1.3 million km² of the Pacific Ocean. This note concerns observations from Phases 1 (Oct.–Nov. 1981) and 2 (April 1982) of a project, supported by the International Development Research Centre and the Memorial University of Newfoundland, and sponsored by the South Pacific Commission. The goal is an integrated control methodology to suppress the vector of Dengue Hemorrhagic Fever (DHF), *Aedes aegypti* (Linn.) (Laird et al. 1982). A full report will follow the completion of Phase 3, early in 1983.

On Funafuti (the group's most populous island, and administrative center) in Phase 1, and on Vaitupu in Phase 2, the DHF vector was recorded from uncharacteristic larval habitats. In particular, it was found to be breeding in the hollow core of papaya (or pawpaw, the commoner South Pacific name) trunks. *Carica papaya*, originally from tropical America (as *Ae. aegypti* hailed from tropical Africa), is now virtually wordwide in the warmer countries, where its fruits are greatly esteemed as are those of the banana. Both the banana and papaya flourish above the slightly brackish ground water that otherwise supports only the staples of coconut, taro and pandanus. The papaya is particularly treasured as one of the world's fastest growing trees and bears fruit when one year old. The delicious, juicy fruit are clustered at the base of the burst of deeply lobed leaves at the top of the hollow trunk (Hargreaves and Hargreaves 1970).

It has long been known that when the soft stem is "perforated by insect or other agency" it "becomes a source of mosquito breeding, which is apt to escape notice" (Dalziel 1937). Although the latter author was writing of West African plantings, he also referred to assertions from China and Mauritius that *C. papaya* has mosquito-repellent properties. This belief had, however, been discounted by Sergent and Sergent in Algeria (1903). Considering the common peridomestic status of papaya throughout the tropical world, it seems surprising that the suitability of that hollow trunk (Fig. 1) for immature stages of *Aedes aegypti* has escaped notice.

One wounded trunk, with a glint of water showing a few centimeters down, was investigated on Funafuti on 15 October 1981. The water was slightly yellowish and the pH was 7.5. Its electrical conductivity was 2300 uS. Four *Aedes (Stegomyia)* larvae were pipetted from it. One was the common Polynesian "bush mosquito," the Bancroftian filariasis vector, *Aedes polynesiensis* Marks. The other three were *Aedes aegypti*. In this as in all other instances now reported, high-

Fig. 1. Papaya trunk, Funafuti, Tuvalu, after chopping into the central cavity to sample aedine larvae.